

# CIRCULATION OF THE OCEANS

Water increases in density with a decrease in temperature and an increase in salinity. Surface waters temperatures in the tropics are relatively constant while those of the temperate regions warm in the summer. The temperatures of polar waters are often below freezing especially those in deep water and can be as low as -2 degrees Celsius due to the high salinity. There is a slow exchange between the ocean's warm surface layers and the cold deep ocean a mile or so below. Cooling in the Polar Regions drives essentially these ocean currents. In the tropics, oceans are relatively stable and water layers are thermally stratified. The upper layers are separated from the cooler layers by a density barrier called the thermocline.

Temperatures decline rapidly towards the thermocline (50-300 meters.) Below it temperatures continue to drop but much more slowly. This feature is a barrier to water movement and consequently dissolved carbon dioxide, but not to particulate carbon bearing matter such as dead phytoplankton. In the middle latitudes, winds can cause considerable mixing of surface and intermediate waters when at certain times of the year the thermocline is nonexistent. In the polar seas, other than on the continental shelf, the thermocline is nonexistent. In rough waters carbon dioxide is dissolved more readily. If it is then cooled, the dense water sinks taking with it the carbon dioxide into the deep ocean.

The effect of winds and ocean currents in equatorial regions can have a pronounced effect on up welling and the thermocline. Thus nutrients are brought to the surface, which increase primary production. This complex of movements in the oceans is still not fully understood but clearly they have a marked influence on the fate of carbon dioxide.